

## Seagrass communities in Exmouth Gulf, Western Australia: A preliminary survey

L J McCook, D W Klumpp & A D McKinnon

Australian Institute of Marine Science, Cape Ferguson, PMB 3, Townsville MC QLD 4810

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### Abstract

A preliminary survey of seagrass communities in Exmouth Gulf, Western Australia, found very low abundances of seagrasses. This seems surprising given the abundance of seagrass beds elsewhere in northern and western Australia, and the highly productive prawn fishery in the gulf; prawn fisheries are usually associated with seagrass systems. Quantitative and qualitative survey of 64 sites, mainly in the inaccessible south and east of the gulf, in September 1994, indicated that seagrasses were neither extensive nor abundant. Percent covers were rarely over 5-10%. Predominant seagrasses were species of *Cymodocea* König, at depths of 0-5 m, and *Halodule* Endlicher in intertidal areas. Species recorded were largely in accordance with published distribution ranges. Subjective assessments indicate that epiphytic and epilithic ephemeral macroalgae contribute significant amounts of production, compared to seagrasses. The lack of extensive seagrass beds is considered in terms of the physical environment of the gulf, and in terms of the carbon source for the highly productive prawn fishery. Despite the ecological and economic importance of seagrasses, this survey is only the second published account of seagrasses for the coast between Shark Bay, Western Australia, and the Gulf of Carpentaria.

### Introduction

Seagrass beds are of major ecological and economic importance to coastal ecosystems, particularly in tropical Australia (e.g. Larkum *et al.* 1989; Poiner *et al.* 1989; Pollard *et al.* 1993); yet very little is known about seagrasses throughout the north-west of Australia. There has only been one published survey (Walker & Prince 1987) of seagrass communities between the Gulf of Carpentaria and Shark Bay (Western Australia), roughly a quarter of Australia's coastline.

In north-east and western Australia, seagrass beds are important in terms of area (Kirkman & Walker 1989; Lee Long *et al.* 1993; Coles *et al.* 1989) and primary production/standing crop (Walker *et al.* 1988; Walker 1989; more generally Klumpp *et al.* 1989; Hillman *et al.* 1989), and as nursery habitats for commercial and recreational fisheries. Seagrass beds in Shark Bay, about 450 km south of Exmouth, are amongst the most extensive, productive and diverse described, with very high standing crops (Walker *et al.* 1988; Walker 1989; Kendrick *et al.* 1990). In the Gulf of Carpentaria, Torres Strait and Great Barrier Reef regions, considerable work has emphasized the extent of seagrass beds and their importance as prawn and fish nurseries (Coles *et al.* 1987, 1989, 1993a,b; Poiner *et al.* 1989; Lee Long *et al.* 1993).

In north-west Australia, Walker & Prince (1987; also Prince 1986, *pers. comm.*) qualitatively surveyed seagrass species distributions at a wide range of locations. Seagrass diversity was found to be high, with an overlap of southern temperate and tropical Indo-Pacific species. These distributions were critical to interpretations of a centre of seagrass diversity and speciation in New

Guinea (Walker & Prince 1987; Kirkman & Walker 1989). More detailed surveys of some north-west shelf marine habitats have been carried out for the oil and gas industries, as far south as Exmouth Gulf, but this information is proprietary (R Hilliard, LeProvost, Dames & Moore Ltd, *pers. comm.*). Poiner *et al.* (1989) identified an urgent need for information on north-west Australian seagrasses.

The present study describes seagrass community composition in Exmouth Gulf, north-west Australia, with an emphasis on the relatively inaccessible and shallow east coast. Exmouth Gulf is a large shallow basin set in a remote, arid tropical area (22°S), enclosed by the Cape Range on the west, and by extremely arid plains to the east (Fig 1). The west coast is largely sand beaches and most of the east coast has a narrow fringe of mangroves bordering extensive salt flats (up to 10 km wide). Rainfall and river runoff in the area are extremely low, and depend on rare floods resulting from cyclones. There is very little published information on marine habitats in Exmouth Gulf, despite its area ( $\approx 3,000$  km<sup>2</sup>) and the presence of a highly productive prawn fishery ( $> 1,000$  tonnes *p.a.*, R Watson, Fisheries Department of WA 1991 and *pers. comm.*) and several oil exploration projects in the area (WA Environmental Protection Agency 1991a, b). There is very little information on the east coast of the Gulf, which is inaccessible by road (Start & McKenzie 1992).

### Methods

The survey, which took place between 24 and 30 September 1994, focused on five areas approximately regularly spaced on the eastern and southern coasts of the Exmouth Gulf, and one area on the west coast (Fig 1).

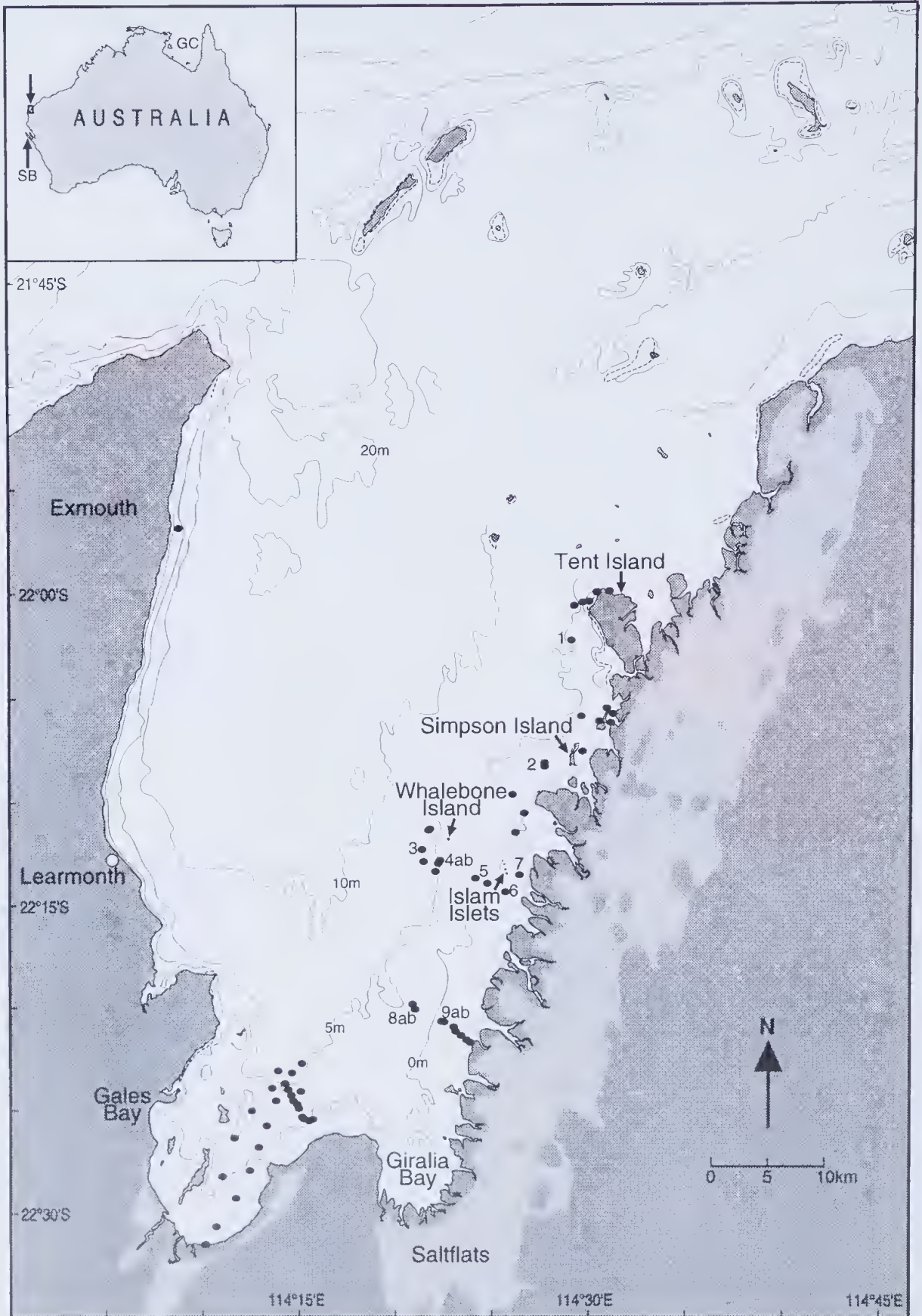


Figure 1. Map of Exmouth Gulf, Western Australia, showing survey sites (●). Numbers indicate sites for quantitative estimates of community composition made on 50 m transects. On the inset, SB and GC indicate Shark Bay and the Gulf of Carpentaria, respectively.



We combined qualitative observations, intended to describe type and extent of benthic vegetation, with systematic quantitative sampling in areas where seagrasses were most abundant. This approach was an adaptation of planned systematic sampling in response to low abundances. Where seagrasses were absent or extremely sparse, quantitative data were not collected. Qualitative spot checks also indicated the representivity of the quantitative data. The west coast site was immediately opposite Norcape Lodge, Exmouth township. The survey focused on the extensive shallow and tidal areas of the southern and eastern gulf, which have little or no road access. Lack of time and navigation information restricted the survey to south of Tent Island.

The quantitative sampling involved estimating abundance of biota at 5 replicate, randomly placed quadrats on a 50 m transect haphazardly laid in areas where spot checks indicated seagrasses to be present in measurable amounts. At each point, we estimated: (i) % cover of seagrasses (by genera, or species where easily distinguished *in situ*) and algae (in functional groups) using 100 points on a 1 m<sup>2</sup> string grid; and (ii) density of seagrasses and any abundant macro-invertebrates using a (50 cm)<sup>2</sup> quadrat (density estimates at site 7, a *Halodule uninervis* bed, used a (25 cm)<sup>2</sup> quadrat, with data scaled accordingly). Density was counted as numbers of erect shoots (leaf groups/clusters) per quadrat. At three sites (4, 8 & 9), we did two transects separated by about 1-200 metres, to indicate variability in abundance (patchiness) at that scale. At sites 2-6, we also collected all plant matter in (50 cm)<sup>2</sup> quadrats for biomass estimates. This material was frozen and later thawed, blotted, separated into above ground and below ground fractions, and wet weighed. Qualitative surveys involved spot checks of benthic community composition, water depth and substrate composition. Where seagrass fronds were not seen, their absence was confirmed by checking for rhizomes in the sediment. Depths were estimated from diving depth gauges and corrected relative to tidal datum by interpolation. Latitude and longitude were determined using a hand-held GPS (Global Positioning System, Motorola Trx 61000A5). Salinity (portable salinometer) and turbidity (secchi disk) were measured as part of another study (McKinnon & Ayukai *in press*). Since this survey focussed on seagrasses, detailed information on algae was not collected. Seagrass specimens were pressed and lodged with the Herbarium of the University of Western Australia.

## Results

Seagrasses were neither extensive nor abundant throughout the areas surveyed. Seagrasses were rare or absent below 5 m (below datum), and even in areas with the greatest abundances, percent cover was rarely over 5% (Fig 2). Extensive areas of shallower water, especially in the southern Gulf (Gales Bay & inshore of site 9, Fig 1) had little or no vegetation, but bare sandy or gravelly substrate, often with a fine film of cyanobacteria. In the shallow mid-east of the gulf, sparse beds of *Cymodocea serrulata* (R. Br.) Aschers. and Magnus and *Cymodocea angustata* Ostenfeld were common between low tide level and 5 m, but these were generally very low in biomass and often patchy. Leaf blade lengths

were generally about 5 cm and always less than 10 cm. We found two dense beds of *Halodule uninervis* (Forsk.) Aschers. in Boissier in shallow intertidal areas near Islam Islets (site 7) and Simpson Islet (east of Burnside Islet) and a small bed of *Syringodium isoetifolium* (Aschers.) Dandy also near Burnside Islet. However, these were limited in extent, relative to the area of apparently similar habitat. Specific searches for roots or rhizomes in the sediments never indicated greater abundances than indicated by above ground shoots.

Quantitative data on community composition (Fig 2) show that even the areas with most abundant *Cymodocea* beds were rarely over 5% cover (maximum cover measured was 6%, but higher cover was noted at the north end of Tent Island). Small amounts of *Halophila ovalis* (R. Br.) Hook F, *Halophila spinulosa* (density  $\leq 16$  m<sup>-2</sup>), *Syringodium isoetifolium* (R. Br.) Aschers. (density  $\leq 144$  m<sup>-2</sup>) and occasionally *Halodule* were present in *Cymodocea* beds, as were species of the algal genera *Caulerpa*, *Halimeda*, *Udotea*, and *Penicillus*, all Chlorophyta.

*Halodule* beds had a higher % cover than *Cymodocea* beds, as well as a high % cover of fairly fine ephemeral algae (Fig 2). However, the mean cover (site 7) was only 21% and these beds were apparently quite limited in extent.

Importantly, there were often large quantities of algae, attached to and/or entangled with the seagrass or attached to shells or subsurface rock. These algae included a wide range of groups, from fine filamentous turfs, through ephemeral epiphytes such as *Hydroclathrus*, *Padina*, *Sporochinus*, *Dictyota*, *Asparagopsis*, *Laurencia*, *Dictymenia tridens*, *Gracilaria* and *Hypnea* to perennial macrophytes, notably *Sargassum decurrens* (R Brown ex Turner) C Agardh and *Sargassum spp.* The ephemeral phaeophyte *Hydroclathrus* was particularly abundant. In some transects, the cover and biomass of these algae was greater than that of the seagrasses, despite the selection of sites on seagrass beds (Fig 2). Indeed, there were extensive, shallow subtidal areas with thick beds of these ephemeral and perennial algae, attached either epiphytically on very sparse seagrass rhizomes, or on hard substrate. Of the areas surveyed, algal beds were most abundant from Tent Island to Whalebone Island/Islam Islets. Large amounts of these species were common throughout the Gulf, both as unattached surface drift, and on the bottom as drift still attached to small fragments of shell etc.

Benthic invertebrates were apparently generally sparse, although we did not sample in detail for burrowing species. Bivalves, starfish, holothurians, small gastropods, decapods and hermit crabs were observed, as well as many small corals, particularly mussids. In one area (site 1, depth 5 m) we found abundant cockles (*Anadara scapha* mean density 38.2 per 0.25 m<sup>2</sup>, standard deviation 7.95), but these cockle beds were not found further south. Amphipods were common on collected plants. Small gastropods and hermit crabs were observed amongst seagrasses, but were not abundant. Plant matter was often observed trailing from burrows in the sediment.

Qualitative observations indicate that the quantitative data are generally representative of areas with most abundant seagrasses. In the area from Tent Island to

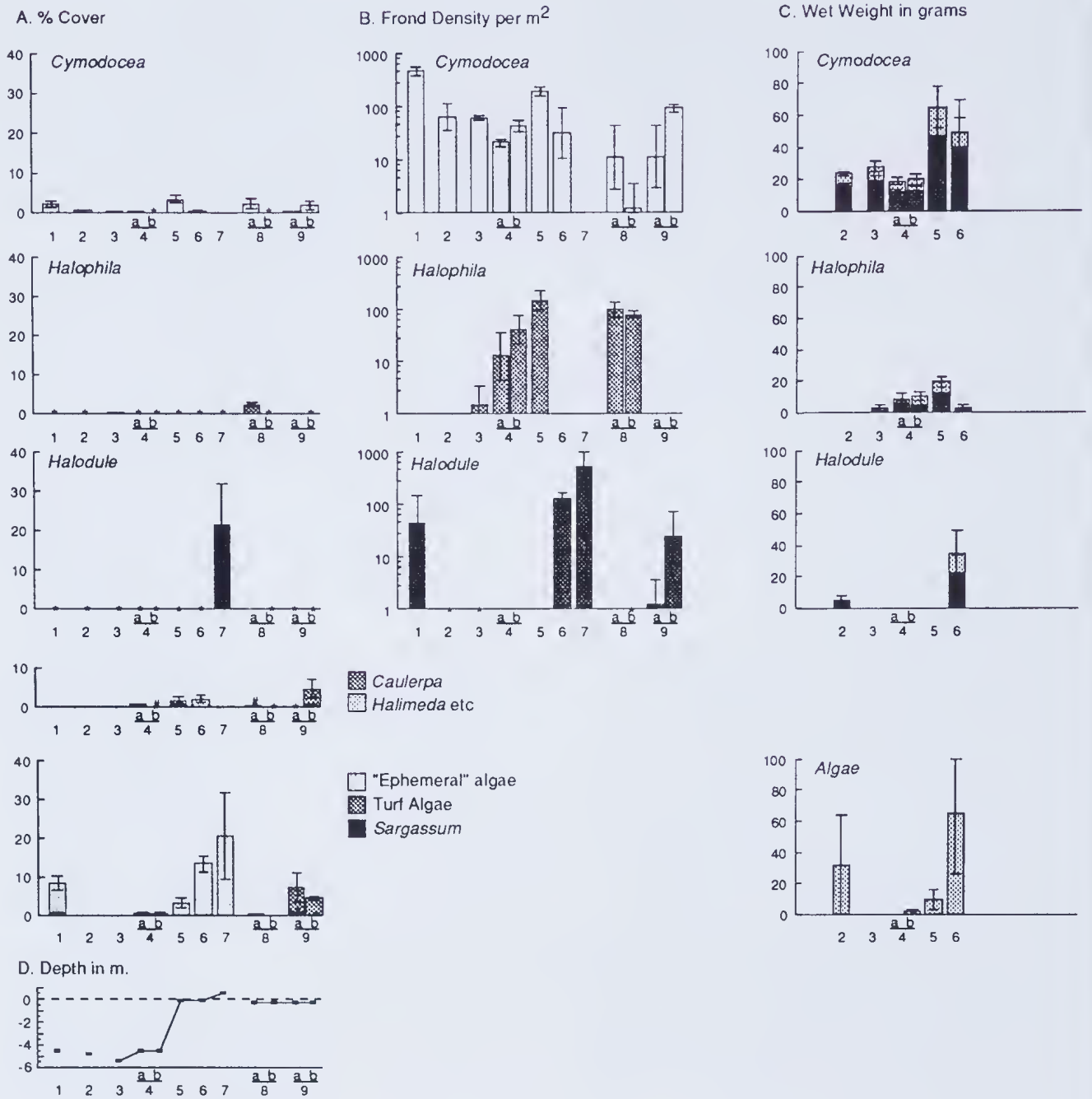


Figure 2. % Cover (A), density (B) and biomass (C) of seagrass and algal groups at a range of sites in eastern Exmouth Gulf. Depths below chart datum are shown in part (D). Site numbers (horizontal axes) refer to Fig 1. Data are mean  $\pm$  se of 5 replicates. % covers of algal groups are shown as cumulative to reduce the number of graphs. "Ephemeral" algae includes non-filamentous but simple, fast growing taxa such as *Hydroclathrus*, *Padina*, *Sporochnus*, *Asparagopsis* and *Dictyota*. Densities were measured in 0.25 m<sup>2</sup> quadrats, scaled to log (density m<sup>-2</sup> + 0.4). \*Asterisks indicate taxa present but < 1% cover or density < 1 frond m<sup>-2</sup>. Biomass estimates are wet weights, divided into below ground (dark shading) and above ground (lighter shading) plant fractions. Wet weight error bars are se of below ground and total weights. Note that biomass estimates are only available for sites 2-6. Samples were not collected at the other sites. As discussed in the text, these data are for the areas with most abundant seagrasses, since quantitative data were not collected where seagrasses were even more sparse.

Islam Islets and Whalebone Island (Fig 1) there were extensive algal beds in the shallow subtidal zone, often attached to hard pavement. Further south, spot checks inshore of site 9 found largely bare substrate with no seagrass, although *Sargassum* was present on hard substrate. Gales Bay, in the south-west, had a largely

bare sandy substrate from 7 m to the intertidal, with occasional sponges, bivalves, tunicates, soft corals and small, filamentous algae and cyanobacteria. *Cymodocea* and *Halophila* were recorded, but in very low abundances. Large numbers of turtles were observed throughout shallow areas surveyed.



On the west coast of the Gulf, near Exmouth town beach, we swam a depth profile from 10 m to the intertidal. At 10 m, seagrasses were absent but sponges, tunicates and seaweeds, and some brown algae were present. By 8 m, brown algae (especially *Sporoclinus* sp) were abundant, as well as invertebrates and small amounts of *Cymodocea* sp, *Halophila ovalis* and *H. spinulosa*. Around 5 metres, *Halophila* species were patchy but common, particularly in sheltered positions behind coral bommies etc. In the shallow subtidal and low intertidal, there were thick beds of *Sargassum*, along with some beds of *Cymodocea* and a small patch of very thick *Thalassodendron ciliatum* (Forsk) den Hartog on rocky pavement (100% cover, but < 100 m<sup>2</sup>). Most of the intertidal zone was bare sand beach.

The shallow waters of Exmouth Gulf were very turbid, with large amounts of suspended material, due to rough sea conditions and strong tidal currents. Apart from a midday lull, the Gulf was very choppy, with chop over 1 m for much of each day, due to strong land and sea breezes. Tidal currents were strong (up to 0.7 knots). Although in deeper areas ( $\geq 5$  m) the bottom was generally fine sand or silt and mud, in shallow areas there was often only a thin veneer of sand or gravel over hard rocky pavement. The bottom sediments appeared to be highly mobile, particularly in shallower areas, and we observed several seagrass beds with exposed rhizomes and roots, where sediments appeared to have been washed away. The highest salinity measured in the Gulf was 38.5 ‰.

## Discussion

Seagrass species recorded in this survey were consistent with patterns found in a previous larger scale survey (Walker & Prince 1987, Table II; also Walker *pers. comm.* and Prince *pers. comm.*), except that our record of *C. serrulata* at Tent Island (22°S) considerably extends the southern limit of this tropical species (Walker 1991). The only other published Western Australian record is from Sunday Island, King Sound (16°S, also recorded as drift at Carnarvon 24°45'; Walker & Prince 1987). All the species recorded have tropical affinities. This is in contrast to Shark Bay where the southern temperate species *Posidonia australis* Hook f. and *Amphibolis antarctica* (Labill) Sonder & Aschers ex Ashers are common, the latter species in extensive and dense meadows (Walker 1989).

Seagrass abundance in this survey was low. Cover was generally less than 5%, mean shoot densities were always less than 1,000 m<sup>-2</sup> and often less than 100 m<sup>-2</sup>, and biomass was generally less than 60-100 g wet wt m<sup>-2</sup>. In contrast, in Shark Bay, 450 km south of Exmouth, *Posidonia australis* and *Amphibolis antarctica* are extremely abundant; *A. antarctica* reaches biomasses of 2 kg dry wt m<sup>-2</sup> and densities of 300-500 shoots m<sup>-2</sup>, each being up to 2 m long (Walker *et al.* 1988), but southerly seagrasses are often more abundant (Coles *et al.* 1989). Also in Shark Bay, Walker *et al.* (1988) recorded 600 leaves m<sup>-2</sup> and 60-100 g dry wt m<sup>-2</sup> of *Halodule uninervis*, and 30% cover of *Cymodocea angustata* as understorey. Just north of Exmouth Gulf, at 21° 16' S, Walker & Prince (1987) found several hundred hectares of *C. angustata* at 30-50% cover. Maximum densities and dry weights of *Halodule*

*uninervis* in the Great Barrier Reef region and New Guinea are also higher than those in Exmouth Gulf (Brouns 1987; Lee Long *et al.* 1993; also Mellors *et al.* 1993). Density and biomass of *Cymodocea* in our study were within the ranges reported for the Great Barrier Reef region (Lee Long *et al.* 1993), but leaves were longer in the Great Barrier Reef region (Coles *et al.* 1987). Biomass records for *C. serrulata* in New Guinea and southern Queensland (148 and >400 g dry wt m<sup>-2</sup> respectively; Brouns 1987; Coles *et al.* 1989) are much higher than our values. Ratios of above and below ground biomass in Exmouth Gulf were similar to those in the literature (Brouns 1987; Moriarty & Boon 1989).

The apparent lack of extensive or abundant seagrass beds in Exmouth Gulf is surprising, given the extent of apparently suitable shallow substrate, the productivity of the gulf, and the contrast with other areas of northern and western Australia. Thus, the low abundance of seagrass recorded in our survey raises three issues: (a) the representivity of the survey; (b) the reasons for the low abundance of seagrass; and (c) the source of carbon production for the Gulf's abundant prawns, turtles and dugongs.

Our results should represent typical seagrass abundances throughout the southern and eastern Gulf. The survey is limited by the locations and particularly the time of sampling, and it remains possible that seagrasses are much more abundant in other areas, or perhaps at other times of year. However, it is very unlikely that all 64 sites fell in areas of particularly low seagrass abundance, especially given our bias to areas of relatively high abundance. Given the turbidity of the water and the clear decrease in abundance between 5 and 10 m, we presume seagrasses to be restricted to shallow areas of the Gulf. It is possible that the unsurveyed northern areas of the Gulf have more seagrass, especially given the trend to very low abundances in the southern Gulf. Lack of time and navigational information precluded survey of the north-east Gulf. Qualitative surveys over the 6 months following our study by M Forde (Bowman, Bishaw & Gorham Ltd, *pers. comm.*) largely confirmed the patterns of abundance and species composition reported here, except for seasonally abundant *Halophila spinulosa* in deeper (15 m) and less turbid water north of the Gulf.

Within the Gulf, there is no indication of higher seagrass abundances at other seasons. We found no sign of dormant or decaying rhizome/root tissues, and July-September 1994 sampling with a grapple dragged on the bottom did not indicate higher abundance or longer fronds (D Pont, M G Kailis Fisheries, *pers. comm.*). Even if seagrass leaf length were to increase at other seasons, cover would remain low without a many-fold increase in density (Fig 2) and root mass. Seasonal changes in tropical seagrasses rarely exceed two-fold changes in standing crop (Mellors *et al.* 1993 for *H. uninervis* on the Great Barrier Reef; Hillman *et al.* 1989; Lanyon *et al.* 1989) and density (Brouns 1987 for *H. uninervis* in New Guinea). In New Guinea *C. serrulata* varied seasonally by only 30% (Brouns 1987). However, just north of Exmouth, Forde (Bowman, Bishaw & Gorham Ltd, *pers. comm.*) reported large changes in *H. spinulosa* above-ground biomass over 6 months, so seasonal differences remain possible. Longer term declines in seagrass abundance may have occurred in Exmouth Gulf (e.g. Poiner

*et al.* 1989), but there has not been any parallel decline in prawn catches (R Watson, Fisheries Department of WA, 1991 & *pers comm*).

The low abundance of seagrasses in the areas surveyed probably results from the lack of suitable substrate. Much of the bottom is either hard substrate or highly mobile coarse sediments, with very little fine silt and clay, and sediments appear to be eroding rather than accumulating (K Woolfe, James Cook University of North Qld, *pers. comm.*). The seagrasses may not be able to accumulate sufficient root mass to stabilise these sediments. Neither salinity nor nutrient levels are likely to be limiting seagrasses. Salinity in the well-flushed Gulf is moderate compared to the reported tolerances (64% for *H. uninervis*, 50% for *C. angustata* (Walker 1989); 45% for *H. ovalis*, 75% for *Halodule* (Hillman *et al.* 1989). Freshwater input to the Gulf is negligible. The abundance of algae on hard substrates suggests that nutrients are not limiting, and the Gulf showed no sign of eutrophication. Trawl disturbance is not responsible for low seagrass abundance, since the areas surveyed are designated a nursery zone (D Pont, M G Kailis Fisheries, *pers. comm.*), and are largely too shallow for trawling.

Assuming that our results do represent seagrass abundance throughout the Gulf, it would seem surprising that the Gulf is a highly productive region. The yearly catch of prawns (*Penaeus latisulcatus*, *Penaeus esculentus*, *Metapenaeus endeavouri*) has been over 1,000 tonnes for 8 of the last 10 years and is not apparently declining (R Watson, Fisheries Department of WA, 1991 & *pers. comm.*). Seagrass beds are important elsewhere to prawn and other fisheries, as nursery areas (Pollard 1984; Coles *et al.* 1987, 1989, 1993a,b; Poiner *et al.* 1989; Bell & Pollard 1989; Lee Long *et al.* 1993; Watson *et al.* 1993; Hill & Wassenberg 1993; less true for *P. latisulcatus*) and probably make major trophic contributions to prawn production via detrital pathways (Klumpp *et al.* 1989). Exmouth Gulf has an estimated dugong population of 1,000 and turtles are very abundant (Prince *et al.* 1981; Prince 1986; Preen *et al.*, James Cook University of North Qld, *pers. comm.*; *pers. obs.*). Both dugongs and turtles are major seagrass grazers.

Our observations suggest that the extensive algal beds are probably major primary producers in this ecosystem. Several previous studies of dense seagrass beds have found that both macroalgae and micro-algae make important contributions to biomass and productivity (Orth & Van Montfrans 1984; Kendrick *et al.* 1990; Klumpp *et al.* 1989; Borowitzka & Lethbridge 1989; Pollard & Kogure 1993). Whilst we did not quantify their contribution, these algal beds apparently have very high turnover and export to deeper water. Most of the species observed are structurally simple, rapid growing, and fragile (especially *Hydroclathrus*). We suggest that rapid growth, high proportional breakage and losses (due to rough conditions), rapid transport by wind and tidal currents, and fast break down would make these algae major sources of detritus throughout the Gulf. Other major primary producers may include phytoplankton and salt-flat cyanobacteria. Phytoplankton production is probably not high, since standing stocks of chlorophyll *a* are low (McKinnon & Ayukai, *in press*). The extensive salt flats (5-10 km wide, Fig 1) in the high intertidal of the southern and eastern Gulf have a thick mat of

cyanobacteria which may contribute significant amounts of carbon during spring tides.

Algal, phytoplankton and salt flat production may thus contribute to the high yield of prawns, via detrital food chains (Klumpp *et al.* 1989). Algal beds may also serve as prawn nursery grounds in this area. Similarly, abundance of suitable algae could sustain large populations of green turtles, which eat both seagrass and algae. However, dugongs are believed to feed on seagrass almost exclusively (Lanyon *et al.* 1989; Erftemeijer *et al.* 1993). It is difficult to explain how an area with low seagrass abundances could apparently sustain a large dugong population. Intertidal *Halodule* beds, such as we observed, are preferred feeding grounds (Lanyon *et al.* 1989). Such beds may be more extensive than our survey indicates, or may be extensive outside our survey area. Exmouth dugongs may also consume unusual amounts of algae, since Lanyon *et al.* (1989) note that dugongs do eat algae when seagrasses are scarce. Given the vulnerable status of dugongs (IUCN 1990), the issue warrants further attention.

In summary, our results suggest that much of the extensive shallow east and south coast of Exmouth Gulf does not have abundant seagrasses, perhaps because of a paucity of suitable substrate. This raises questions about primary production in a region with high prawn production and herbivore populations. We suggest that beds of ephemeral and perennial algae may be important primary producers in the region.

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